

Theoretical Physics Group

Dao Thi Nhung and Le Duc Ninh on behalf of the group

Institute For Interdisciplinary Research in Science and Education (IFIRSE),
ICISE, Quy Nhon

Centro Brasileiro de Pesquisas Físicas - International Center of
Interdisciplinary Science Education,
MoU signing ceremony, Quy Nhon, 5 July 2019



Physics in Vietnam: A personal view

- ▶ Public research institutions: Vietnam Academy Of Science And Technology (VAST) (mostly in Hanoi and Ho Chi Minh city), many public universities (Vietnam National University in Hanoi and in Ho Chi Minh city, Quy Nhon University, ...).
- ▶ Private research institutions: Ton Duc Thang University (Ho Chi Minh city), Duy Tan University (Da Nang), Phenikaa University (Hanoi), ICISE (Quy Nhon), ...
- ▶ International universities: Vietnamese-German University (Ho Chi Minh city), Vietnamese-French University (Hanoi), The American University in Vietnam (Da Nang), ...
- ▶ Physicists are mostly at VAST (historical reasons ?), but many young people now are moving to private institutions for better salaries and working environment.

IFIRSE-Theory: History and Facilities

- ▶ Since 1 October 2016 (we are now at the 3rd year)
- ▶ Location: ICISE, Ghenh Rang, Quy Nhon, Vietnam
- ▶ Website: https://ifirse.icise.vn/theoretical_physics/
- ▶ Facilities: 3 working offices (1 large office for students, shared with the Neutrino group), a few computers, an ICISE's guest house nearby (for students and visitors), other facilities at the conference center.
- ▶ Computing resources: very limited by now. So far, computing resources for our calculations have been kindly provided by our collaborators at Humboldt University in Berlin, KIT Karlsruhe, Germany; and by LAPP Annecy, France.
 ~> *International collaborations are important !*
- ▶ Administrative: done by the ICISE's secretariat

Scientific members

- ▶ Staff members:
 - ▶ Dr. Dao Thi Nhung (PhD in 2012)
 - ▶ Dr. Le Duc Ninh (PhD in 2008)
- ▶ Collaborators who have been visiting ICISE:
 - ▶ Dr. Julien Baglio (Universität Tübingen, Germany)
 - ▶ Dr. Geneviève Belanger (LAPTh, France)
 - ▶ Dr. Le Tho Hue (Institute of Physics, Hanoi, Vietnam)
 - ▶ Dr. Phan Hong Khiem (University of Science in Ho Chi Minh city, Vietnam)
 - ▶ Dr. Sabine Kraml (LPSC Grenoble, France)
 - ▶ Prof. Dr. Margarete Mühlleitner (KIT, Karlsruhe, Germany)
 - ▶ Dr. Vo Quoc Phong (University of Science in Ho Chi Minh city, Vietnam)
- ▶ and **Students** (next)

Training students: 10/2016 - 7/2019 [<https://ifirse.icise.vn/theses/>]

Excellent students have been coming to the group and have achieved solid results:

- ▶ Mr. Nguyen Quoc Viet (Ho Chi Minh city): bachelor thesis (2017) on “**muon pair production at e^+e^- colliders in the SM Effective Field Theory and Z boson polarization**” \leadsto Master scholarship in Paris \leadsto PhD in neutrino physics in Paris.
- ▶ Mr. Vuong Pham Ngoc Hoa (Ho Chi Minh city): bachelor thesis (2017) on “**top-quark pair production at e^+e^- colliders in the SM Effective Field Theory and W boson polarization**” \leadsto Master scholarship in Paris \leadsto PhD in theoretical physics in Grenoble.
- ▶ Ms. Le Truong My Hau (Quy Nhon): bachelor thesis (2018) on “**Compton scattering in QED**” \leadsto Now a teacher at a high school.
- ▶ Mr. Tran Quang Loc (Ho Chi Minh city): bachelor thesis (2018) on “**Constraining Wilson coefficients in the SM Effective Field Theory from LEP1 data**” \leadsto Master in physics.
- ▶ Mr. Nguyen Tran Quang Thong (Ho Chi Minh city): a bachelor thesis (2019) on “**Scatterings of proton proton to leptons in the Standard Model**”.
- ▶ Mr. Phan Anh Vu (Ho Chi Minh city): a bachelor thesis (2019) on “**Higgs masses in the Next-to-Minimal Supersymmetric Standard Model with inverse seesaw mechanism**”.

Very good **bachelor** students.

They come here for a **3-month internship** and get financial support from IFIRSE.

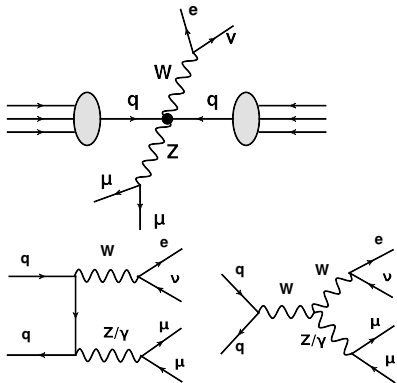
Research directions

So far, we have been working mainly on phenomenology of particle physics at the LHC:

- ▶ **Precision** calculations in the Standard Model (SM): next-to-leading order (NLO) QCD and EW corrections to multi-boson, single top quark production
- ▶ Searching for **new physics** effects using SM effective field theory
- ▶ **Supersymmetry**, **Higgs** phenomenology in the (Next-to-)Minimal Supersymmetric Standard Model (NMSSM)
- ▶ **Two-loop** calculations of the Higgs boson masses in the NMSSM
- ▶ Develop automated **tools**: NMSSMCal (with Prof. Mühlleitner's group), VBFNLO (with Prof. Zeppenfeld's group), Lilith (with Dr. Sabine Kraml)

Some recent research results

$W^\pm Z$ production at the LHC



- ▶ Initial beams: unpolarized
- ▶ Only left-handed quarks interact with W (max. asymmetry)
- ▶ Z interacts with both left- and right-handed quarks, but with different coupling strength:

$$g_R^f = -(s_W Q_f)/c_W,$$

$$g_L^f = (I_f^3 - s_W^2 Q_f)/(s_W c_W).$$
- ▶ \leadsto W and Z produced at the LHC are polarized!

Remark: those polarized W and Z induce an asymmetry in angular distributions of the final-state leptons \leadsto **polarization fractions**

Precision physics in gauge-boson polarization

Three polarization fractions of a W or Z boson: $f_0 + f_L + f_R = 1$
SM predictions [Julien Baglio, LDN arXiv:1810.11034] vs. measurements [ATLAS arXiv:1902.05759]:

Method	$f_0^{W^+}$	$f_L^{W^+} - f_R^{W^+}$	f_0^Z	$f_L^Z - f_R^Z$
ATLAS data	0.26{8}	-0.02{4}	0.27{5}	-0.32{21}
LO	0.247	0.126	0.214	-0.472
NLOQCD	0.241	0.082	0.232	-0.307
NLOQCDEW	0.244	0.078	0.237	-0.244

- ▶ NLO corrections are important, even for polarization fractions (for cross sections NLO QCD is about +50%, NLO EW about -5%).
- ▶ EW corrections are small for W, but large for $f_L^Z - f_R^Z$, about 20%.
- ▶ About 3σ deviation for $f_L^W - f_R^W$, but the error is large.

The Next-to-Minimal Supersymmetric Standard Model

- ▶ SM + Supersymmetry \leadsto Minimal Supersymmetric Standard Model (MSSM)
- ▶ MSSM + a singlet scalar (S) \leadsto NMSSM:
 - ▶ Solve the so-called “ μ ” problem: The superpotential includes

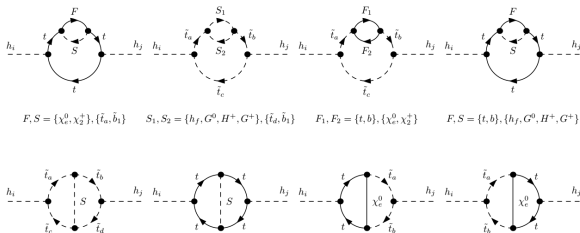
$$\mu \hat{H}_1 \hat{H}_2 \rightarrow \lambda \hat{S} \hat{H}_1 \hat{H}_2 - \frac{\kappa}{3} \hat{S}^3 \quad (1)$$

- ▶ Less finetuning compared to the **MSSM**

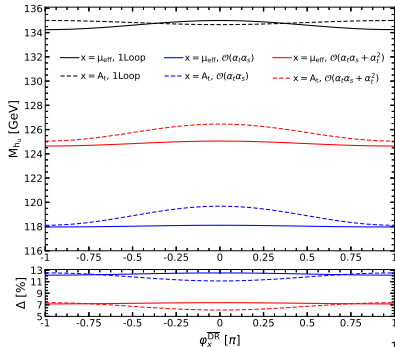
$$(M_h^{\text{tree}})^2 < M_Z^2 \cos^2(2\beta) + \lambda^2 v_S^2 \sin^2(2\beta) \quad (2)$$

However, we know now that $M_h = 125$ GeV and the (N)MSSM are still alive. How possible ?

Higgs mass @ 2 loop [Dao, Gröber, Krause, Mühlleitner, Rzehak 2019]



- ▶ α_t : top-Yukawa coupling
- ▶ CP-violating phase ϕ_x : ϕ_μ (full lines), ϕ_{A_t} (dashed lines)
- ▶ 2-loop $\mathcal{O}(\alpha_s \alpha_t + \alpha_t^2)$ correction can be about -10%



Automated tools for HEP

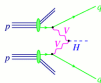


VBFNLO - A parton level Monte Carlo for processes with electroweak bosons

You are here: Overview

Overview

- Project Members
- Download VBFNLO
 - Software Download
 - Beta Version
 - Formfactor Calculation Tool for aGC
 - Changelog
 - Known Issues
 - Optimised Grids
 - Parallel Runs
- Newsletter
- Documentation
 - Manual
 - Process List
 - Installation
 - Running VBFNLO



Project Description

VBFNLO is a fully flexible parton level Monte Carlo program for the simulation of vector boson fusion, double and triple vector boson production in hadronic collisions at next to leading order in the strong coupling constant. VBFNLO includes Higgs and vector boson decays with full spin correlations and all off-shell effects. In addition, VBFNLO implements CP-even and CP-odd Higgs boson via gluon fusion, associated with two jets, at the leading order one loop level with the full top-quark and bottom-quark mass dependence in a generic two Higgs doublet model.

NMSSMCALC

Calculator of One-Loop and $O(\alpha_t \alpha_s + \alpha_t^2)$ Two-Loop Higgs Mass Corrections and of Higgs Decay Widths in the CP-conserving and the CP-violating NMSSM New: $O(\alpha_t^2)$ corrections to the Higgs boson masses

The program package NMSSMCALC calculates the one-loop and $O(\alpha_t \alpha_s + \alpha_t^2)$ corrected Higgs boson masses and the Higgs decay widths and branching ratios within the CP-conserving and the CP-violating NMSSM.

The decay calculator is based on an extension of the program HDECAY 6.10 [now](#).

Authors: Julien Baglio, Ramona Gröber, Marcel Krause, Margarete Mühlleitner, Dao Thi Nhung, Heidi Rzehak, Michael Spira, Juraj Streicher and Kathrin Walz

Program: NMSSMCALC version 3.00 NEW! $O(\alpha_t^2)$ corrections to the Higgs boson masses

A tool for constraining new physics from Higgs measurements
by Jérémy Bernon and Béranger Dumont

Version 2 by Sabine Kraml, Ninh Duc Le, Nhung Thi Dao, Loc Tran Quan ... to be released on GitHub

Other activities and research grants

- ▶ We organize the Vietnam School of Physics on particle physics and cosmology every two years (2016, 2018, 2020, ...): Students from Asian-Pacific countries
- ▶ In collaboration with MCnet, we organize a Monte-Carlo event generator school at ICISE (9/2019)
- ▶ Our research projects are supported by the Vietnam National Foundation for Science and Technology Development (NAFOSTED).
- ▶ For more information and publications:
https://ifirse.icise.vn/theoretical_physics/

Thank you for your attention!